It must be stated, however, that this reproduction is correct in part only, because many of the intervals amount to less than a semitone, and cannot therefore be expressed by the customary system of musical notation.

Among the Eskimos near Bering strait the intonation is very similar. A sergeant of the U. S. Army who was stationed near Norton sound, repeated the songs to me. Even the senseless text is the same with the exception that the *a* in *ah ja* is more like *a*^{n}: with other words it is entirely nasal. It seems that in former times the southern Greenlanders had a similar song. The well-known Eskimo Joe sang for me a series of notes the shades of which could doubtless be analyzed with the aid of a series of Hemholtz's resonators. Parry furnishes in his "Second voyage for the discovery of a Northwest passage" (p. 542), the song of the inhabitants of Winter island. Although decidedly lugubrious some of these phrases nevertheless move over two and a half intervals. The text is *Amna Aya Aya Amna ah*, similar to that of the Itanese and the other inhabitants of Greenland.

From these brief remarks it may be seen that the Inuit from West Greenland to the shores of Bering strait possess a common ancient song, a song which in the course of time has undergone less modification than even their language.

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OPINIONS UPON CLAY STONES AND CONCRETIONS

BY L. P. GRATACAP.

CLAY dogs, clay stones or clay concretions are terms indifferently applied to a singular class of objects which occur in clay beds of recent or Quaternary age, in spots where conditions favorable for their development have existed. They certainly strike the eye as remarkable in their curious mimicry of the shapes of birds and beasts, and in the capricious complexity of their forms. The question inevitably provoked by them: How were they made? has received an answer of a generic character, including under one process the phenomena of spherulites in lava, septaria in iron ores, flints in chalk, nodules in sandstone, peastone in limestones, the hexagonal columns of basalt, the structure of granite boulders, geodes of quartz, segregations of iron pyrites and the simple and complicated shapes shown upon the accompanying plates, viz., by *concretionary action.* Concretionary

action has been assumed to indicate a cohesive and attractive property in matter when finely divided, and when its particles possess some or considerable freedom of motion, whereby molecules of the same sort gather together in bunches or globes, sometimes coat over coat, the whole enlarging until the limit of cohesive action around that center has been reached, or the expanding circumference of one concretion meets and impinges upon its growing neighbors in a mass affected throughout by this "toward-a-center" movement. This is a partial confession of ignorance as to what the essential nature of the process is. We are led to believe from the analogy in all these cases enumerated above, that the action is the same, and perhaps it is, but modified by varying conditions and the constitution of the substance influenced.

It is doubted whether basaltic columns can ascribe their formation to concretionary action, and it is plainly stated that geodes arise from the entrance of saturated solutions from without, through fissures, into the cavities formed within clay or other nodules, by internal shrinkage, of which process the familiar hollow iron ore balls are a good illustration.

The authorities are not inclined to throw much light upon this curious phenomenon, regarding it as an ultimate fact in nature. Dana gives no explanation of this process (Manual, 1879, pp. 85, 86, 87, 88) but illustrates it in various figures. In the Manual, 1875, he speaks of concretions "having the form of, or containing spheroidal concretions; some varieties are also called globuliferous when the concretions are isolated globules and evenly distributed through the texture of a rock; others are oölitic when made of an aggregation of minute concretions not larger than the roe of a fish." He speaks of one example as "a crystalline rock with spherical concretions imbedded in its mass and not separable from it * * * each layer (of the three forming each concretion) consisting of different minerals, for example, garnets the center, feldspar the middle layer and mica the outer, and all making a solid mass. The constitution of such concretions is very various. In rocks containing feldspar they usually consist largely of feldspar and sometimes of feldspar alone or of feldspar with some quartz. The concretions in pitchstone and pearlstone (called spherulites) are almost purely feldspathic, and often separate easily from the rock." He figures

concretions in sandstone, and one notable one where in the areolets included between the cracks of an argillaceous sandstone, concretions have formed, bounded by the polygonal sides of the cell. Unfortunately there is no word said as to the nature of the concretion, whether entirely like the rest of the rock, nor whether the entire sandstone partakes of this nature. He also alludes to crystallized bunches of quartz and pyrite as instances of concretionary action, remarking that "this tendency in nature to concentric solidification is so strong that no foreign nucleus is needed."

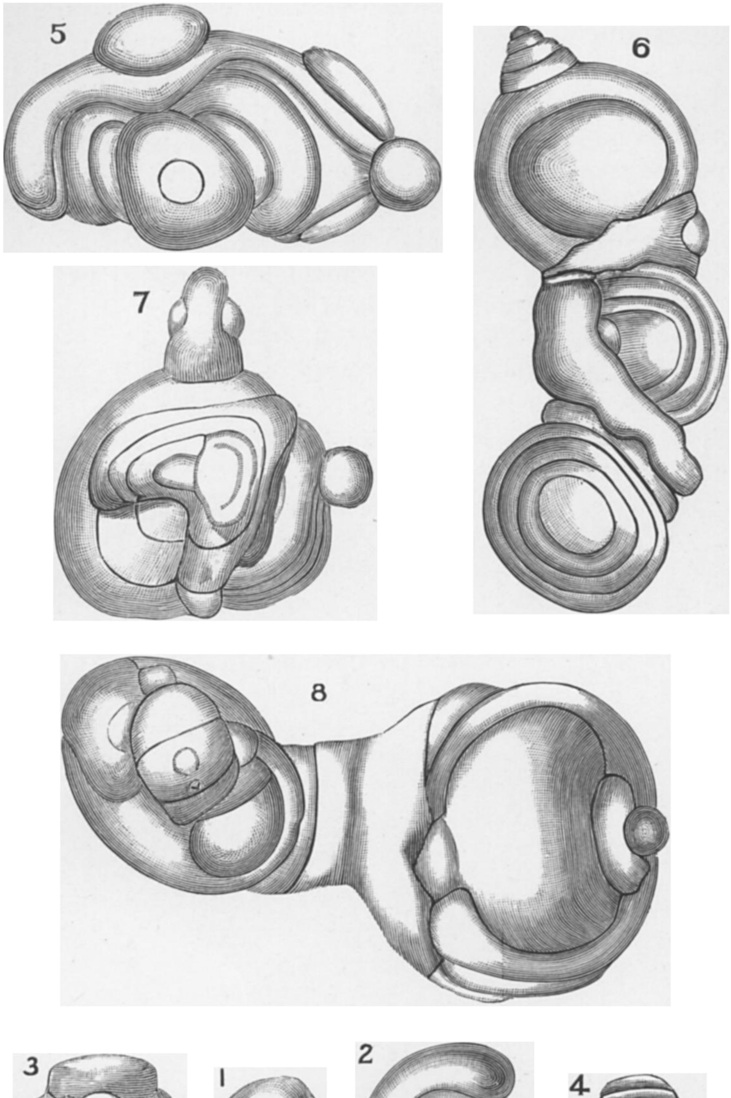
In the Text Book for 1883 he says much the same thing in abbreviated form, referring with more doubt to the concretionary character of basaltic columns, but defining the process as "the result from a tendency in matter to concrete or solidify around centers."

Le Conte, in his Manual of Geology, devotes three pages to concretions, explaining them as occurring "whenever any substance is diffused in small quantities through a mass of entirely different material. Thus if a stratum of sandstone or clay have small quantities of carbonate of lime or carbonate of iron diffused through it, the diffused particles of lime or iron will gradually, by a process little understood, segregate themselves into more or less spherical or nodular masses, in some cases almost pure, but generally inclosing a considerable quantity of the material of the strata. In this manner lime balls and iron ore balls and nodules, so common in sandstones and clays, are formed. In like manner the flint nodules of the chalk were formed by the segregation of silica, originally diffused in small quantities through the chalk sediment. Very often some foreign substance forms the nucleus about which the segregation commences."

Dr. Dawson, in a note upon cone in cone structures in his Acadian Geology, says of ordinary concretions, "they are in general attributed to the mutual attraction of particles diffused through masses of sediment and aggregating themselves around solid bodies as nuclei, or flowing into cavities of fossils and other places of least resistance."

Professor A. H. Green, in his Manual of Geology, says, speaking of laboratory concretions in chemical solutions and precipitates: "That nodules are being formed in the same way in some rocks now in the course of deposition. It is usual to speak of

PLATE XXVI.



this process as concretionary action. There is no objection to be raised to this phrase, and it or some similar term may be safely and conveniently used to express the fact that certain matters have been separated out of the body of the rock and collected together in balls, provided always we bear carefully in mind that by giving the process a name we do not get any nearer to understanding the manner in which the result has been brought about. If any one asks us what made the nodules, we may, if we like, say concretionary action; but if the awkward question is put, What is concretionary action? we should be somewhat puzzled for an answer. We know that one of the ingredients of a mixture has been extracted from the surroundings and gathered into lumps; how exactly this was done we do not know. The term, in fact, is only a way of stating our ignorance, and, unless due precaution be taken, a somewhat dangerous way, because to certain minds it looks like an explanation."

This remark of Professor Green echoes the German couplet:

> "Denn eben wo Begriffe fehlen
> Da stellt ein Wort zur rechten Zeit sich ein."

Archibald Geikie says (Text Book of Geology): "Concretionary, containing or consisting of mineral matter which has been collected either from the surrounding rock, or from without, round some center so as to form a nodule or irregularly shaped lump. This aggregation of material is of frequent occurrence among water-formed rocks where it may be often observed to have taken place round some organic center such as leaves, cones, shell-fish remains or other relics of plants or animals. Among the most frequent minerals found in concretionary forms as constituents of rocks are calcite, siderite, pyrite, marcasite and various forms of silica. In a true concretion the material at the center has been deposited first and has increased by additions from without, either during the formation of the enclosing rock or by subsequent concentration and aggregation. Where, on the other hand, cavities and fissures have been filled up by the deposition of materials on their walls and gradual growth inward, the result is known as a secretion."

M. Virlet, on the 20th January, 1845, presented to the Geological Society of France, a paper upon this subject, in which he claimed that concretionary masses had been formed subsequently to the deposition of the rocks or layers in which they were found,

by a molecular displacement, the particles of the concreting substance being gathered together by some action similar to electrical action. The paper elicited from M. Becquerel assent in the following words: "A mass of geological facts adequately show that there has been and is yet, in different rocks, centers of action around which foreign substances and their compounds gather. There is no doubt that these transferences of molecules may have been effected by forces analogous to electricity, but it is not sufficient to suppose that the phenomenon has an electrical origin, it is necessary to prove it; this is what I have already done in a certain number of cases by reproducing these compounds," &c.

M. Virlet, in the same paper, compiles a chronological statement of the views held by geologists and chemists previous to his own publication, from which the following notes are taken.

In 1816 Mr. Buckland speaking of nodular siliceous beds and the flints of chalk, says they seem to have been formed whilst the material which encases them was yet soft, and to have reached their hard or solid condition almost contemporaneously. The separation of the silica from the calcareous mass would have been achieved through the attractive forces which drew the siliceous particles towards certain centers. In 1834 M. de La Beche remarks, "that we see in the rocks of mechanical origin certain very remarkable aggregations which must have been produced by the mutual attraction of the molecules which compose them." He remarks that these nodules contain more carbonate of lime than the marls and argillaceous schists which surround them, and in allusion to their laminated character says, "that we can scarcely doubt that they have been formerly the continuation, one of the others. The molecules of calcareous matter have separated themselves from the marls to unite as we now see them, and we would not probably be mistaken greatly if we assumed that the beds of the particular deposit, without containing sufficient carbonate of lime to form successive beds, contain nevertheless too much of it to remain disseminated in the marls without being gathered into small masses."

Mr. Babbage showed that siliceous particles form concretionary-like bodies in the clay preparations used in the manufacture of porcelain. M. Virlet objects to the finding of any analogy in the two cases, as the pottery mass has been formed at once and the natural beds have been deposited slowly over long periods.

Sedgewick considered concretions very interesting, inasmuch as they indicate that the determining causes are due to some débris, either animal or plant, or some small invisible grain which he remarks is in accord with what experience has taught us in the precipitation and crystallization of salts, which ordinarily are determined by the presence of foreign bodies in the midst of a saturated solution. The same action, as seen in the formation of calculi in the bladder, he discerns in nature, and regards the presence of strange bodies as formative of concretionary centers, where the material separated from the different beds has gathered together. The principle of all this he suggests may be bound up in the assertion that like seeks like.

M. Turpin, speaking of siliceous concretions in the chalk, says if we admit that the nodules of flint owe their transformation to the decomposition of innumerable plants or animals, which live either in salt or fresh water, and upon these marine or lacustrine floors the débris or the entire bodies of these beings fall and pile themselves up upon each other, so as to form great beds, more or less thick, made up of everything, if we recall that these animals are made up in great part, first, living organic matter, second, calcareous material, third, silica, these two last having been absorbed and secreted molecularly and confusedly in the interstices of the first; if, in this pasty bed, gelatinous and very liquid, that we may call *barégine*, a bed where all is mixed, we admit, as appears proven, the separation, more or less complete, of siliceous particles, and the conglomeration of the first amidst the second, as the globules of blood and those of milk, for sake of comparison, separate from the serum to form clots, we can imagine that any natural object, organic particle, &c., might form the center of their concretionary growth or be enveloped in their outward extension. M. Virlet thinks M. Turpin proves too much, and that if such an attraction were universally so, clay beds or siliceous limestones would not be homogeneous but form themselves into beds of nodules of silica and lime.

Lyell, in his Elements of Geology, thinks that the molecules were held in suspension in water; once deposited, those which have a similar nature appear to exercise mutual attraction upon each other and gather in certain spots, where they form heaps, nodules and concretions. He instances the celebrated beds of magnesian limestone in the north of England, where the size of

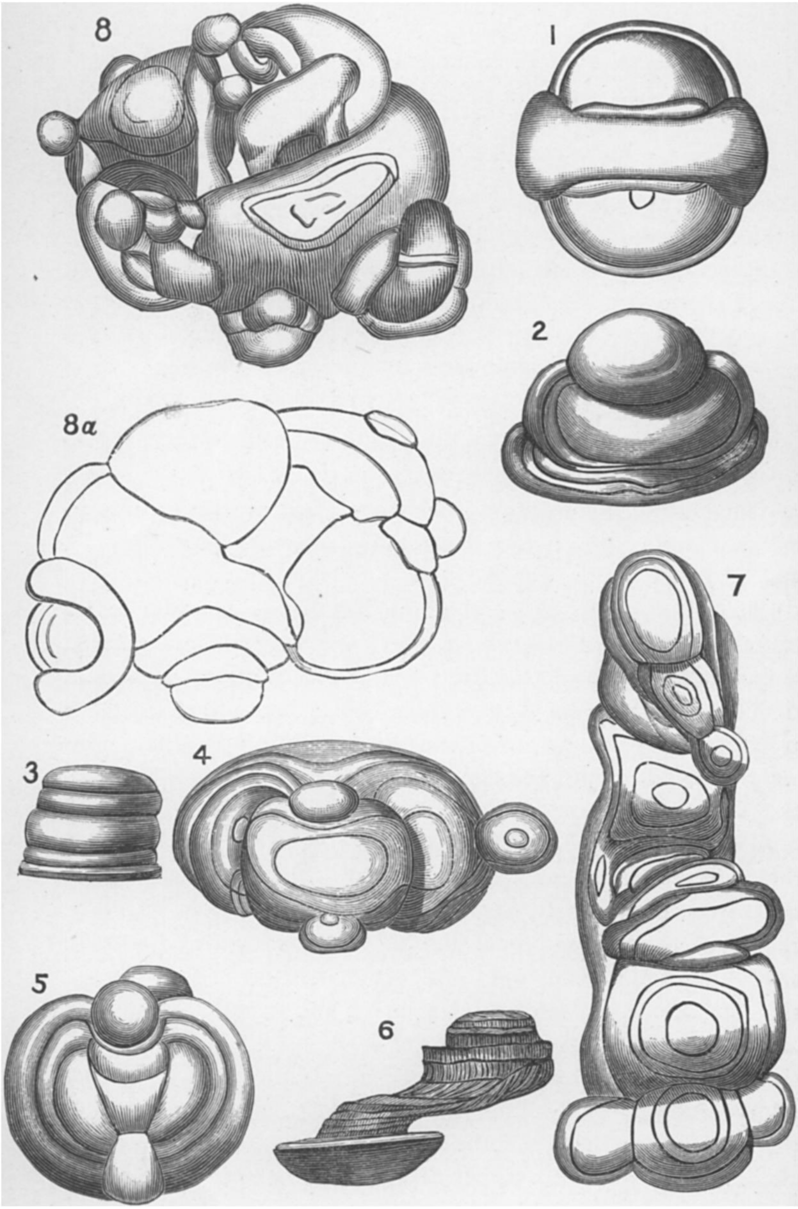
the spherical concretions greatly varies from that of a pea to those many feet in diameter, while they are intersected by the laminæ of the original deposit.

The stones of Imatra, which have attracted much attention and are like our clay dogs, have been studied by M. Parrot, who has ventured to classify the irregular shapes under the names of monotypes, ditypes, tritypes, tetratypes, pentatypes and polytypes. Hypotheses to explain these have been various; first comes the gyration theory, which is inadmissible; the stalactitic theory explains them by infiltration, the vegetable theory regards them as fossil toadstools, another theory considers them as coprolites, the animal theory, which M. Parrot defends, considers them as the remains of petrified animals similar to Medusæ.

Bowerbank and Parkinson attributed many flints to a coralloid origin as being alcyonaria which had attracted silex and had been covered with a gray crust presenting no trace of organization, and that they had then been penetrated by chalcedonic flint, red or purple, which had replaced the molecules of the animal matter as it decomposed.

In Vol. IV, 2d series, Transactions Geological Society of London, Dr. Fitton, in his paper upon the strata below the chalk, says, "all stages of gradation can be perceived from distinctly separated concretions of stone to others so nearly uninterrupted that the next step into perfect continuity can be easily conceived;" again he writes, "in all these cases the concretions must have been formed after the deposition of the sand which includes them, and probably beneath a great depth of compacted materials. In such a mass, shut off from the free access of air and change of temperature, there is no obvious reason for disturbance of affinities which maintained the original form of the components, except the decomposition of the animal and vegetable remains diffused among the stony substances, yet here we have not only solid limestone, where nothing but loose sand and gravel were before, but firm siliceous concretions pervading, and so identified with the separated particles of the quartzose sand that the whole is nearly homogeneous. If the decomposition of the organized substances, continually acting throughout very long periods of time be not sufficient to produce the whole of these effects, perhaps it may be supposed that electricity is the cause which sets free the elements and disposes them anew."

PLATE XXVII.



In the special instances of concretions known as clay stones—carbonate of lime, clay, sand and iron—two writers have treated of them at considerable length. Parrot, in the Memoirs of the Academy Sciences St. Petersburg, Vol. v, 6th series, gives a very extended examination of the stones of Imatra, which ends very inconclusively with assigning them to an organic origin. His figures are very interesting, and differ considerably from the familiar forms of the Connecticut valley.

Professor Hitchcock, in the Geology of Massachusetts, devotes considerable time to them, and his remarks are most important. He considers them as formed by the crystallization of calcite in clay, that lateral accretion predominates, from the easier movement in the clay particles sideways, that different localities have different forms, and that they are laminated by growth from segregation in successive layers of the clay bed. He seldom finds nuclei.

The writer's examination of a collection of these objects seems to warrant the following conclusions:

1st. That in their formation they have passed through a preliminary or soft stage, before hardening, more or less long (Pl. XXVI, Fig. 7; Pl. XXVII, Fig. 1).

2d. That the process of a concretion has formed a center about which others gathered; has, as it were, precipitated and induced more extended action of the same sort (Pl. XXVI, Fig. 5).

3d. That the approach to solidity of a concreting mass is attended with a development of new centers around which concretions form (Pl. XXVII, Figs. 7-8).

4th. That the tendency of matter is to concrete around a center from all sides equally, but that if there is deficiency of material, on the side where the material is plentiful, the form will correspond (Pl. XXVI, Figs. 2, 5, 6).

5th. That concretions lie parallel to the bedding, are flattened vertically, are wider than high (Pls. XXVI, XXVII).

6th. That the upper surfaces are varied and in relief, while the bottoms are apt to be flat (Pl. XXVII, Fig. 8).

7th. That the concretion is often plainly built upwards by the superimposition of many films (Pl. XXVII, Figs. 2, 3, 6).

8th. That the amount of carbonate of lime varies: according to Hitchcock, 43 per cent to 56 per cent; Parrot 51 per cent to 55 per cent; Swedish, 60 per cent to 61 per cent; the writer, 45.63 per cent.

9th. That the concretions vary in specific gravity: Parrot, 2.5, 2.49, 2.54, 3.34; the writer, 2.60, 2.57, 2.67, 2.59.

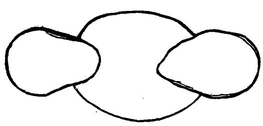
10th. That many show periods of growth (Pl. xxvi, Figs. 4, 6; Pl. xxvii, Fig. 5).

Further, the results of microscopic examination have been these: A horizontal, equatorial section of an oblate concretion, when examined with an one-eighth objective, showed an area densely crowded with crystalline points of calcite, so closely packed as to resemble a patchwork of fine mosaic, of which the separate pieces varied in *apparent* size from ¼ to ½mm. This was seen in polarized light. No apparent variation in their number between the center and circumference of the disk was noted, but there were evident crowds or congeries of these shining specks in places, though usually their distribution was uniform.

Between crossed Nichols irregular and loosely connected dark blotches or clouds appeared over the field between which, in the lacunæ, shone transparent plates of calcite varying in size. Black lines in labyrinthine reticulations seemed to outline the calcite crystals, the latter lying in their meshes.

A cross vertical section revealed no linear arrangement of calcite crystals, and in the slide in question the minute tesselation of the horizontal section was repeated upon a possibly denser and more microscopic scale, whilst between crossed Nichols the spots, loops and blotches of clay became very noticeable.

A horizontal section through a group of three concretions showed the subjoined outlines, when a plane surface was ground for its attachment to the glass, the outlines of the two side concretions being very faint.



The section presented, under the microscope, no differing features from those examined before, unless the groupings of calcite specks were slightly more marked. The clay lines seemed larger and more meshy, like a net. On removing the calcite with hydrochloric acid the clay remaining on the slide presented a surface of perforations. The apertures varied in size, indicating the comparative size of the calcite crystals removed by the acid, though many such openings were previously filled up with packed calcite lenses. Sometimes the holes left by the removed calcite were inclined tubes, and the fenestration was like a bryozoan surface. The acid washed on the thin film though quite

strong, did not entirely remove the calcite, it lingered still, entrapped in the clay particles.

The assumption which may combine these features and accords with microscopic examination seems to be this: That in the clay beds where these dogs occur there were variously shaped spots or irregular separations between layers where moisture remained for a long time, keeping the clay in a plastic, more or less liquid form, and that with the withdrawal of water to these points, the soluble carbonate of lime was also gathered there. This latter became concentrated by the contraction of the magma, or through introduction of more carbonate of lime in solution in percolating waters.

Upon concentration the carbonate of lime crystallizes within the mass and one crystal speck thus appearing would form a center of growth around which the new crystals would gather, drawing in clay with them. If this action occurred in a narrow seam-like plane the concretions would be flat, if in a wider area more spherical Sphericity of growth seems an ultimate principle, but contraction of space and thinness of the concreting layer for the most part causes the concretions to expand symmetrically all around.

Where spots of this character coincide one over the other in rising layers of the clay beds, a pillar is formed, where they connect obliquely a slanting pile of disks is made (Pl. XXVII, Fig. 6). As the material in one of these areas becomes consolidated, we may suppose the upper surface to become denser and crystallization beginning at a number of points the surface is broken up in a number of separate forms. Thus the small wart-like bodies would seem to have formed quickly and to have become fixed at once.

This growth may have been quite gradual or quite rapid, but in all cases due to the concentration of the calcite solution in the clay magma and then its crystallization. It could have been interrupted, irregular, more on one side than another, two or three or more concretions may have originated at the same time and grown towards each other, or interfered and enveloped each other in endless diversity of ways. One concretion may have become the center around which others grew, or a small concretion may have formed in the midst of a larger one, the quantity and state of the carbonate of lime varying from point to point. A certain

freedom or play of the particles, *i. e.*, a certain plasticity, seemed necessary to secure symmetrical forms, beyond which the magma simply hardened without form, as in the amorphous bands connecting concretions or overlapping them (Pl. XXVI, Figs. 8 and 6), or underlying them.

The peculiarity noticed in many of the concretions of their apparent growth upward by films or from a side, is analogous to the habit of crystallizing fluids which begin to form crystals along the line of attachment, and this in some cases seem dependent on the lamination of the clay beds.

It is singular, and I find Professor Hitchcock makes the same observation, that in the Fontainebleau limestone, with as much or less carbonate of lime in their composition, the calcite has carried the sand into its rhombohedral forms, which it has failed to do with the clay in the clay stones. It would seem that in the former case the carbonate of lime crystallized rapidly and *en masse*, as it were, in the sand, whereas in the latter the calcite formed more or less slowly, and was disseminated in minute points through a *plastic* mass of clay.

NOTE.—In Pl. XXVII, fig. 8*a* is the under view of fig. 8—a flat surface.

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THE CONDYLARTHRA.

BY E. D. COPE.

(Continued from page 805, August number.)[1]

PHENACODONTIDÆ.

THE genera of this family display a uniformity in the structure of the true molar teeth not seen in the Periptychidæ. Their range of grade is seen in the premolars, especially those of the superior series. Thus in Protogonia, all of those teeth have but a single external lobe. In Phenacodus the fourth has two external lobes. In Diacodexis the second, third and fourth teeth have two external lobes. The premolars are unknown in Anacodon. While Protogonia is primitive in its superior premolars,

[1] It is necessary to notice two errata which occur in the part of this paper already published in the last number of the NATURALIST. In the diagnosis of the suborder Hyracoidea, page 792, line 10, fibula is printed instead of tibia. The same error occurs on page 793, line 13. Second, the figures of *Ectoconus ditrigonus* are natural size, and not two-thirds of it, as stated.